Children's problem-solving in serious games: The "Fine-Tuning System (FTS)" elaborated

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Obikwelu, Chinedu Okwudili, Read, Janet C ORCID: 0000-0002-7138-1643 and Sim, Gavin Robert ORCID: 0000-0002-9713-9388 (2013) Children's problem-solving in serious games: The "Fine-Tuning System (FTS)" elaborated. The Electronic Journal of e-Learning, 11 (1). pp. 49-60.

Children's Problem-Solving in Serious Games: The "Fine-Tuning System (FTS)" Elaborated

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Abstract: For a child to learn through Problem-Solving in Serious games, the game scaffolding mechanism has to be effective. Scaffolding is based on the Vygotzkian Zone of Proximal Development (ZPD) concept which refers to the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers. Scaffolds in serious games are learning stimulators. The effectiveness of these learning stimulators lies in the way they are managed or regulated. Scaffolds that are not regulated could lead to expertise-reversal effect or redundancy effect which inhibits learning. In the current classroom application of serious games, the game-based learning stimulators remain the same for everyone ("blanket scaffolding") – the learning stimulators are not managed or regulated. In order to make scaffolding in serious games more effective for classroom use, the calibration of the game's learning stimulators has to be enabled – this would help in meeting the changing needs of the learners. The concept of fading which is critical to scaffolding is introduced to serious games, to facilitate the fine-tuning of the learning stimulators to the changing needs of the learners. This paper seeks to address the issues in the design and implementation of a Fine-Tuning System for serious games based on the fading concept. Also discussed in this paper are the factors to be considered in the implementation of the Fine-Tuning System in serious games. These include fading decisions; fading and learning rates; optimal scaffolding distance; classroom culture and collaborative learning. The adverse effects of neglecting fading such as expertise-reversal effect and redundancy effect are also discussed.

Keywords: expertise-reversal effect, redundancy effect, fading, adaptable, serious game, fine-tuning system, problem-based learning, scaffolding, ZPD, peer-tutoring

1. Introduction

"The ZPD is the distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978). Scaffolding situations are those in which the learner gets assistance or support to perform a task beyond his or her own reach if pursued independently when "unassisted" (Wood, et al., 1976). Scaffolded Problem-Based environments present learners with opportunity to engage in complex tasks that would otherwise be beyond their current abilities. (Hmelo-Silver, et al., 2007). A scaffold is by definition, a temporary entity that is used to reach one's potential and then removed when learners demonstrate their learning (Lajoie, 2005). Scaffolding is the guidance required in bridging the gap between what a child knows and what he is supposed to know. For this to take place, scaffolds (learning stimulators) are used. These learning stimulators are gradually removed as the child becomes more knowledgeable. Serious games which are games that go beyond entertainment to educating the players (Rankin, et al., 2008) require an effective scaffolding mechanism to guide and stimulate learning. An ineffective scaffolding mechanism can lead to expertise-reversal effect. Expertise-Reversal Effect is demonstrated when instructional methods that work well for novice learners have no effects or even adverse effects when learners acquire more expertise (van Merrienboer & Sweller, 2005). It is important therefore to fade the support as the learner gains expertise.In essence each time the player attains the game (learning) goal the scaffolding level is reduced. "A critical piece to the concept of scaffolding is fading. If the scaffolding is successful, students will learn to achieve the action or goal without the scaffolding. For students to practice the action or goal without the scaffolding, the scaffolding must fade" (Guzdial, 1994). Introducing the Fine-Tuning System (FTS) to serious games, would enable calibration of learning support in the games. The FTS works with a scaffolding regulator which facilitates the generation and fading of support. This paper focuses on the design and implementation of the FTS. Subsequent sections would cover related work on serious games and scaffolding; current application of scaffolding in children's serious games; problems and solutions; the fading concept; eliminating "Expert Reversal Effect": The Essence of fading; scaffolding approaches based on fading; the basis of

Reference this paper as: Obikwelu, C, Read, J, and Sim, G. "Children's Problem-Solving in Serious Games: The "Fine-Tuning System (FTS)" Elaborated" *The Electronic Journal of e-Learning* Volume 11 Issue 1 2013, (pp49-60), available online at www.ejel.org

the FTS; design considerations; the fine-tuning system; Challenges and Limitations; conclusions and future research.

2. Related work on serious games and scaffolding

An analysis of literature surrounding the design and development of serious game reveals an array of models and frameworks that ensure effective pedagogical and design principles. Table1 below presents a number of these models and frameworks along with a brief description of the expected learning process. Regarding the learning process, providing guidance to students has been necessary to enhance their learning experience (Melero, et al., 2011). The ZPD is a critical concept to consider when providing scaffolding (Dennen, 2004). Assisting students within their ZPD is a personalized process (Dennen, 2004). Though some of the models have instructional support features such as system feedback, debriefing etc, the vital piece of individualizing this support is ignored. There's the challenge of providing instructional support for many children in a class, each with different needs (Dennen, 2004). None of the frameworks show how the guidance provided by a serious game can work effectively for multiple ZPDs found in the classroom.

Table 1: Models and frameworks for serious games

Model/ Framework	Learning
Problem-Based Gaming (PBG) Model	This model is founded on the basis of Problem-Based Learning (Kiili, 2007). It is based on the experiential learning theory (Kolb, 1984) The model describes learning as a cyclic process through direct experience in the game world and a reflection on this experience. The model emphasizes reflective thinking and also makes it clear that reflection may take place in isolation or with collaboration with other people. According to (Kiili, 2007) the feedback that the game provides from a player's actions should support reflective thinking and knowledge construction by focusing a player's attention to relevant information from the learning point of view. This is only possible if the feedback (a form of scaffold) is ZPD-specific. Little emphasis is laid on scaffolding which is not enough to tag the framework suitable for the dependent learner.
RETAIN design and evaluation Model	This model aide in the evaluation of how well the academic content is endogenously immersed and embedded within the game's fantasy and story context, promoters transfer of knowledge, and encourages repetitive usage so that content becomes available for use in an automatic way. (Gunter, Kenny, & Vick, 2008). This model is restricted to the standalone system, thus little or no emphasis on collaboration, which only networked users engage in. For the dependent learner, collaboration is an important part of the learning process.
Input-Process-Output Model	In this model there is an instructional program that incorporates certain features or characteristics of games that trigger a cycle that includes user judgement/ reaction, user behaviours and system feedback. The instructional content is paired with appropriate game features to produce self motivated game-play. This engagement in game-play lead to the achievement of training objectives and specific learning outcomes (Garris, et al., 2002). The system feedback here is discussed in relation to motivation with little emphasis on its effect on performance. There's also the debriefing process that provide the link between the game cycle and the achievement of learning outcome (Garris, et al., 2002). According to (Garris, et al., 2002), debriefing is a fundamental link between game experiences and learning. Though debriefing is essential for scaffolding (as indicated in this framework), there should also be collaboration through interaction with peers.
Game Object Model (GOM)	The Amory and Seagram's Game Object Model (GOM) attempts to create dialectic between pedagogical dimensions and game elements (Amory & Seagram, 2003). In GOM, educational games are considered to consist of a number of components (objects) described through abstract and concrete interfaces which represent the pedagogical/ theoretical and design elements respectively. The abstract to concrete interface in GOM represent a transition from conceptualization to realization. In GOM, Game Space Object includes Visualization Space Objects which drives cognitive apprenticeship. The GOM has evolved, so there is GOM

Model/ Framework	Learning
	version II. GOM version II establishes the need for collaboration in the learning process (Amory, 2007). In GOM, the place of scaffolding through instructional support is unclear.
Kiili Experiential Gaming Model	The model describes learning as a cyclic process through direct experience in the game world and learning is defined as a construction of cognitive structures through action in the game world (Kiili, 2005). This is described to consist of a solution loop, an experience loop and solution bank (Kiili, 2005). Solution loop: The player generates solution required to overcome challenges. The solution process is most fruitful if it is performed in groups (Kiili, 2005) Experience loop: Here the player tests the solutions. This model discusses the flow experience and links it to the clarity of goals and appropriateness of feedback. Also vital is reflection, described here as reflective observation of the feedback. This leads to the construction of schemata and enables the discovery of new and better solutions to problems. The model substantiates that problems can be solved collaboratively, but also makes it clear that critical reflection and knowledge construction occurs in a private world (Kiili, 2005). Reflection and collaboration which are essential for PBL are emphasized in this model. Scaffolding is also a critical aspect of this model. This model emphasizes flow and covers reflection, collaboration and scaffolding which are elements of PBL.
The Game-based Learning Framework	According to (Staalduinen & Freitas, 2011), this model is constructed by integrating instructional design theories and educational game design models. The following make-up the framework Contextual background: a game design should always be embedded in an educational theory. The framework is designed for multiplayer games within a constructivist perspective. Game elements and learning outcomes, including feedback and debriefing Game-play and player motivation: This is based on flow theory, with regard to clear goals, active player feedback and sense of control. This is combined with engagement theory to incorporate challenge, fantasy, curiosity, and control. (Staalduinen & Freitas, 2011) The framework has a learning, instruction and assessment column. Essential to a good learning experience is the alignment of the three columns (Staalduinen & Freitas, 2011). This framework says nothing about how the player learns, so collaboration and reflection is not emphasized. It is suppose to serve as a checklist and a reminder for designers of serious games (Staalduinen & Freitas, 2011)
6"I"s Model	A Hierarchy of serious game elements – identity, immersion, interactivity, increased complexity, informed teaching and instructional. This model functions as a hierarchy with identity as the basic foundational element (Annetta, 2010). This model is based on the constructivist viewpoint that people learn through ascertaining prior schema and ultimately constructing new knowledge by connecting a new experience to a prior experience (Annetta, 2010).The model also introduces the idea of informed learning. Specifically, this entails embedding scaffolds (learning support) into a game design and unique to educational games, the idea of embedded assessments for educational learning outcomes (Annetta, 2010). There is also the concept of immediacy which refers to those communication behaviours that reduce perceived distance between people (Thweatt & McCroskey, 1996) cited in (Annetta, 2010). According to (Annetta, 2010) photorealistic environments and facial movements and expressions by other players (in a multiplayer context) and nonplayer characters increase immediacy.Immediacy just as informed learning scaffolds learning and thus could facilitate PBL.

The table uses an analysis of frameworks to show the extent to which serious games have adopted the principle of scaffolding. From the analysis of these selected frameworks, it appears that scaffolding has been relatively unstudied by researchers in this field. It however seems that distributed intelligence is being assumed to be scaffolding in serious games , there is an argument that this is not scaffolding “if the support does not fade, then one should consider the activity to be distributed intelligence, not scaffolded achievement” (Pea, 2004). Also neglected is fading which is essential in scaffolding.

3. Current application of scaffolding in children’s serious games

The learning stimulators (scaffolds) are structured in such a way as to keep the child focused on the learning goal. These learning stimulators in serious games include the feedbacks and hints. Good feedback can significantly improve learning processes and outcomes if delivered correctly (Shute, 2007). Formative and summary feedbacks are the two distinct types of feedback found in serious games. Formative feedbacks are the games’ real-time reaction to the actions taken by the child in the game. It is often the response the child or player-learner look-out for when testing his hypotheses in the game. Summary feedback is a delayed response – often in the form of a progress report that the child can reflect on to improve his actions in the game. Hints are regarded as pointers to the problem solutions - problem solutions should be complex enough to require many interrelated pieces and should motivate the students’ need to know and learn (Hmelo-Silver, 2004). The pointers are expected to guide the child to the problem solutions. The structuring of these pointers (hints) would determine how effective they’ll be in the game.

In the current application of scaffolding, these learning stimulators are often used in conjunction with expert/teacher debriefing. Here the teacher’s response or feedback to the child on assessing the child’s progress-report often aims at re-focusing the child towards the learning goal. It often externalizes self-reflection by directing appropriate questions to the child (Hmelo-Silver, 2004).

This current application of scaffolding in children’s serious games is depicted in (Obikwelu, et al., 2012) conceptual model of the scaffolding mechanism in serious games

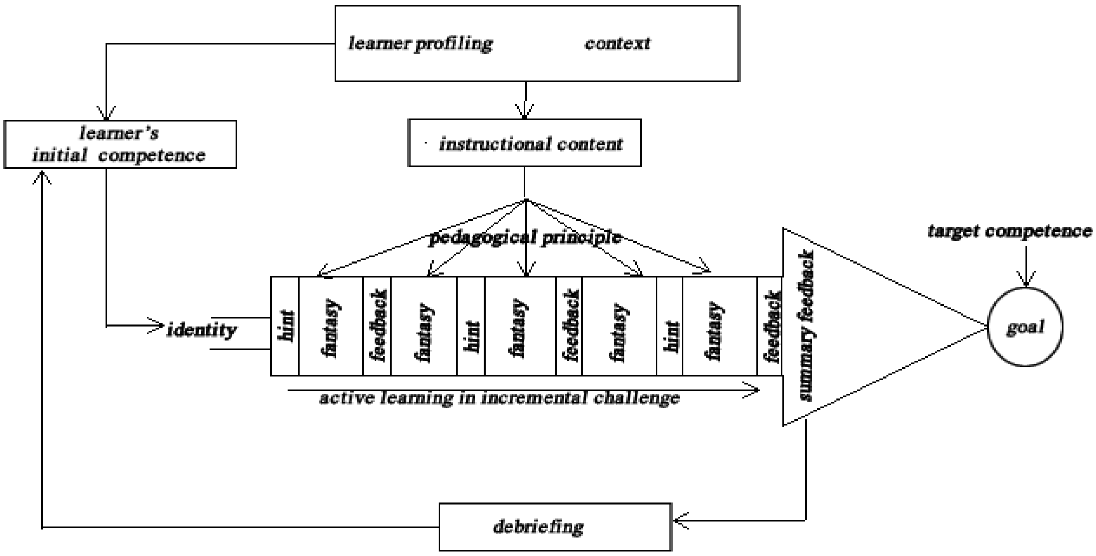

Figure 1: The serious game scaffolding model (Obikwelu, et al., 2012)

It is important that the scaffolds are adapted to the learner. In the current application of scaffolding this is not the case -the learner is adapted to the scaffolds. The scaffolds remain the same despite the changing level of expertise of the learner. “Support should be calibrated and sensitive to the changing needs of the learner” (Puntambekar & Hubscher, 2002).

4. Problems and Solutions

An analysis of the literature depicts scaffolding in serious game as

- Instructional support/ debriefing given by an expert/teacher after game-play (Garris, et al., 2002)
- Inculcating learning through the mastery of a challenge (Gunter, et al., 2006) and Learning support embedded into game design (Annetta, 2010).

Instructional support through debriefing is given by an expert/teacher after game-play (Garris, et al., 2002). However the problem with this approach is that it is not possible for one person to provide support for the multiple students learning at different rates within their ZPDs. (Puntambekar & Hubscher, 2002) The Zone of Proximal Development refers to the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers (Vygotsky, 1978). It is difficult to provide the adaptive and dynamic support that is tailored to every individual in a classroom situation (Puntambekar & Hubscher, 2002).

Inculcating learning through the mastery of a challenge as described by (Gunter, et al., 2006) and learning support embedded into game design (Annetta, 2010) is faced with the problem of unsuitability for multiple ZPDs. In the complex environment of the classroom, there are multiple Zones of Proximal Development (ZPDs) that have to be taken into consideration while building scaffolding (Puntambekar & Hubscher, 2002). These multiple ZPDs are not taken into consideration while embedding learning support into serious games. The critical need to providing the right amount of support for every learner is over-looked. All learners get the "same" scaffolding – "blanket scaffolding", contradicting the very notion of scaffolding (Puntambekar & Hubscher, 2002). If the support does not fade, then one should consider the activity to be distributed intelligence, not scaffolded achievement (Pea, 2004).

5. The fading concept

In scaffolding, the ultimate goal is the removal of scaffolds, since we want students to be able to complete the task independently (McNeill, et al., 2006). This removal of scaffolds is referred to as fading. Because excessive or insufficient support can hamper the learning process, it is critical to determine the right type and amount of support and to fade at appropriate time and rate (van Merrienboer, et al., 2003). The danger of fading learning support that is not individualized is that it may fade too quickly and reside outside of a child's ZPD (McNeill, et al., 2006). There is need for the individualization of this embedded learning support to suit multiple ZPDs. For this reason the concept of generating and fading scaffolds is introduced. This would be done by introducing a scaffolding regulator to create a fine-tuning system within a serious game.

6. Eliminating "expertise reversal effect": The essence of fading

Feedbacks are the most important scaffolds in serious games. Feedback can broadly be categorized into corrective and explanatory feedback. The choice of feedback in the game should be based on the child's prior knowledge of the concept to be learned. Explanatory feedback is used to guide novice students in the process of meaning making; it promotes deeper learning than when corrective feedback is used alone (Moreno, 2003). The feedback could have a positive or negative influence on learning. If the feedback is inappropriate for the learner, it would be ineffective and thus deter learning. Thus the feedback should be adaptable and sensitive to the changing need of the learner. Fading would facilitate this. It is important to note that feedbacks could be visual or auditory, thus enabling the fading and calibration of visual and auditory content in games would help meet the changing needs of the learner. Kalyuga et al (2000) demonstrated that if experienced learners attend to auditory explanations, learning might be inhibited (Kalyuga, et al., 2003). Auditory explanations may also become redundant when presented to more experienced learners (Kalyuga, et al., 2003).

"Kalyuga et al (1998) and Yeung et al. (1998) proposed that, for experienced learners, eliminating redundant material is advantageous because it reduces the cognitive load associated with processing redundant information in working memory" cited in (Kalyuga, et al., 2003). As the learner gain expertise, the scaffold should be removed. Providing additional text is redundant for experts and will have negative rather than positive effects, thus demonstrating the expertise reversal effect. The most important instructional implication of this effect is that, to be efficient, instructional design should be tailored to the level of experience of intended learners (Kalyuga, et al., 2003).

7. Scaffolding approaches based on fading

Supportive Scaffolding: As supportive scaffolding fades, the task is the same as it was before, but the goal is for the learner to have internalized the procedures and concepts which had been scaffolded (Jackson, et al., 1998). This entails fading the hints and feedbacks (in the game) widely associated with scaffolding.

Intrinsic Scaffolding: As the scaffold fades, the task is changed, but associations should remain so that the learner can progress from simpler, more structured or more concrete tasks to variations in which more of the underlying complexity or abstractness is introduced (Jackson, et al., 1998). The difficulty of the task is hidden from the player and gradually introduced as the scaffold fades.

Reflective Scaffolding: It is the support for thinking about the task (e.g. planning, making predictions, evaluating). It also doesn't change the task itself, but instead it makes the task of reflection explicit by eliciting articulation (Jackson, et al., 1998). An example is the art of conversation in serious games - the player character conversing with the Non-Player Character (NPC). The fading options here could include gradually disabling the conversions starting with the most to the least helpful.

8. The Basis of the FTS

Scaffolding implies a coupling between two changing levels: the level of competence embodied in the student on the one hand, and the level of competence embodied in the level of scaffolding (Geert & Steenbeek, 2006). Discrete levels of support can provide the necessary flexibility such that each student is facilitated in performance and learning without being stifled by too much scaffolding or being left to flounder by too little scaffolding (Guzdial, 1994). Scaffolding involves calibrated support for diagnosed learning targets (Azevedo & Hadwin, 2005). On this basis there is need to enable the calibration of this support in serious games. This is made possible in the FTS by the scaffolding regulator. The adjustment can be made by the player-learner, teacher or an internal decision process. According to (Guzdial, 1994), adaptable scaffolding is the scaffolding which can be changed or faded by the user while adaptive scaffolding is one which changes or fades based on an internal decision process.

9. Design considerations

9.1 Fading rate

In principle, the serious game should be designed with sufficient learning support for all the ZPDs. To achieve this, there is need for a scaffolding regulator which is designed to fine-tune learning support to suit each ZPD. The learning support for various learners could be regulated by the teacher from a centralized point using the scaffolding regulator. This is done by gradually fading the support as learners complete tasks within the game. "The rate of fading depends upon the child's level of development and competence. A teacher is fading when the level and/or the amount of support is decreased over time" (van de Pol, et al., 2010).The rate of fading for various learners will be established and categorised into a number of distinct groups. The learners for which the rate of fading is slower would be categorized as the non-expert peers, while the learners for which the rate of fading is faster would make-up the expert group.

The fading decision can either be made by the teacher or the child. Based on the fading decision, fading rate can be categorised into two major types: Perceived Fading Rate and Actual Fading Rate.

Perceived Fading Rate: This is the fading rate adapted by the teacher with the assumption that it is the most suitable for the students.

Actual Fading Rate: The rate at which a child fades the support as determined by the child himself. A child's learning rate can be extrapolated from the Actual Fading Rate. "One problem is that it may be hard for the child to make fading decisions" (Jackson, et al., 1998)

9.2 Collaborative learning

"When a child's ability, or competence, is assessed on some static, independent test, this measure reflects his actual level of development; and this is true whether the measure is a standardized test or the laboratory experiment familiar to developmental psychologists" (Brown & Reeve, 1985). The child's transition from this actual level of development to his potential level of development would require collaboration with a more knowledgeable peer. "Vygotsky argues that what children can do with the assistance of others is "even more indicative of their mental development than what they can do alone" (Vygotsky 1978)" cited in (Wagner, 2007).

"According to Vygotsky's theory, problem solving skills of tasks can be graded on (1) those performed independently by a student; (2) those which can be performed with help from others and (3) those that cannot be performed even with help. The second situation occurs in the classroom collaborative environment" (Pivec, et al., 2003). The term "collaborative learning" refers to an instruction method in which students at various performance levels work together in small groups toward a common goal – The success of one student helps other students to be successful (Gokhale, 1995). Proponents of collaborative learning claim that the active exchange of ideas within small groups not only increases interest among the participants but also promotes critical thinking (Gokhale, 1995). It is important to understand that collaboration is not the same as co-operation. When people are co-operating, they are adjusting their actions so that each player achieves their individual goals, whereas collaboration is about actions being adjusted in order to achieve a shared goal (Watkins, 2009). It can be argued that most two-player games designed to enhance collaboration end up facilitating co-operation. Collaboration which is a core tenet of the FTS requires that the trainer and students play non-traditional roles such as interaction and collaboration with each other within the educational process (Pivec, et al., 2003). Collaborative learning aims to promote dialogue. Dialogue enhances understanding when learners explain to each other (Watkins, 2009).

9.3 Peer tutoring

Peer tutoring is one type of peer collaboration (Hoysniemi, et al., 2003). Peer-tutoring is an approach in which one child instructs another child in material on which the first is an expert and the second is a novice (Damon & Phelps, 1989). "As a form of collaborative learning, peer tutoring is important because it provides the kind of social context in which normal discourse occurs: a community of knowledgeable peers . This is the main goal of peer-tutoring" (Bruffee, 1995) In peer tutoring the expert peer assumes the role of the tutor and the non-expert peer is the tutee. Peer-tutoring involves people from similar social groupings who are not professional teachers helping each other to learn, and learning themselves by teaching (Topping, 1996). Peer-tutoring is characterized by specific role-taking: at any point someone has the job of tutor, while the other is in a role as tutee (Topping, 1996). Peer group influence requires an effective peer tutor training course based on collaborative learning, one that maintains a demanding academic environment and makes tutoring a genuine part of the tutors' own educational development (Bruffee, 1995). This form of collaboration have the following advantages – the teacher would have more time to spend instructing students with more severe academic deficits and the expert-peer who is the student tutor would acquire teaching skills and improve his own academic performance as a result of the tutorial experience (Harris & Sherman, 1973). In addition there is the tendency of the non-expert peer establishing a trusting relationship with a peer (expert) who holds no position of authority which might facilitate self-disclosure of ignorance and misconception, enabling subsequent diagnosis and correction.

10. The "fine-tuning system" (FTS)

Figure 2 shows how this system works within the serious games context. It depicts the relationship between fading, game progress and knowledge gained. As the scaffold is faded the distinction between the expert peer and non-expert peer become obvious.

Prior to fading, everyone – expert and non-expert would make satisfactory game-progress with little knowledge gained. This is because the learning support for the entire target ZPDs were embedded in the game. This support is gradually faded, and at point B the game-progress for some of the students would fall below a set threshold. These students would be regarded as the non-expert peer. At this point those who still make satisfactory game-progress are regarded as the expert peer. As soon as this distinction is made, the expert peer and the non-expert peer are made to collaborate through peer-tutoring. This collaboration would considerably improve the game-progress made by the non-expert peer and thus significantly increase the knowledge gained in the field through game-play.

Furthermore figure 3 is a graphical illustration of the relationship between a child's competence and fading

Vygotsky, pointed out that a person can imitate only that which is within her developmental level (Vygotsky, 1978). From this viewpoint, we can argue that the target scaffolding level should be within the target learners' learning bandwidth. This implies that fading can only go as far as the potential/target competence.

The dotted curve in figure 2 represents the non-expert peer who is yet to attain the potential competence which the expert peer has already attained at the target scaffolding level. It is important to note that fading beyond the target scaffolding level would not make a difference in the child's competence.

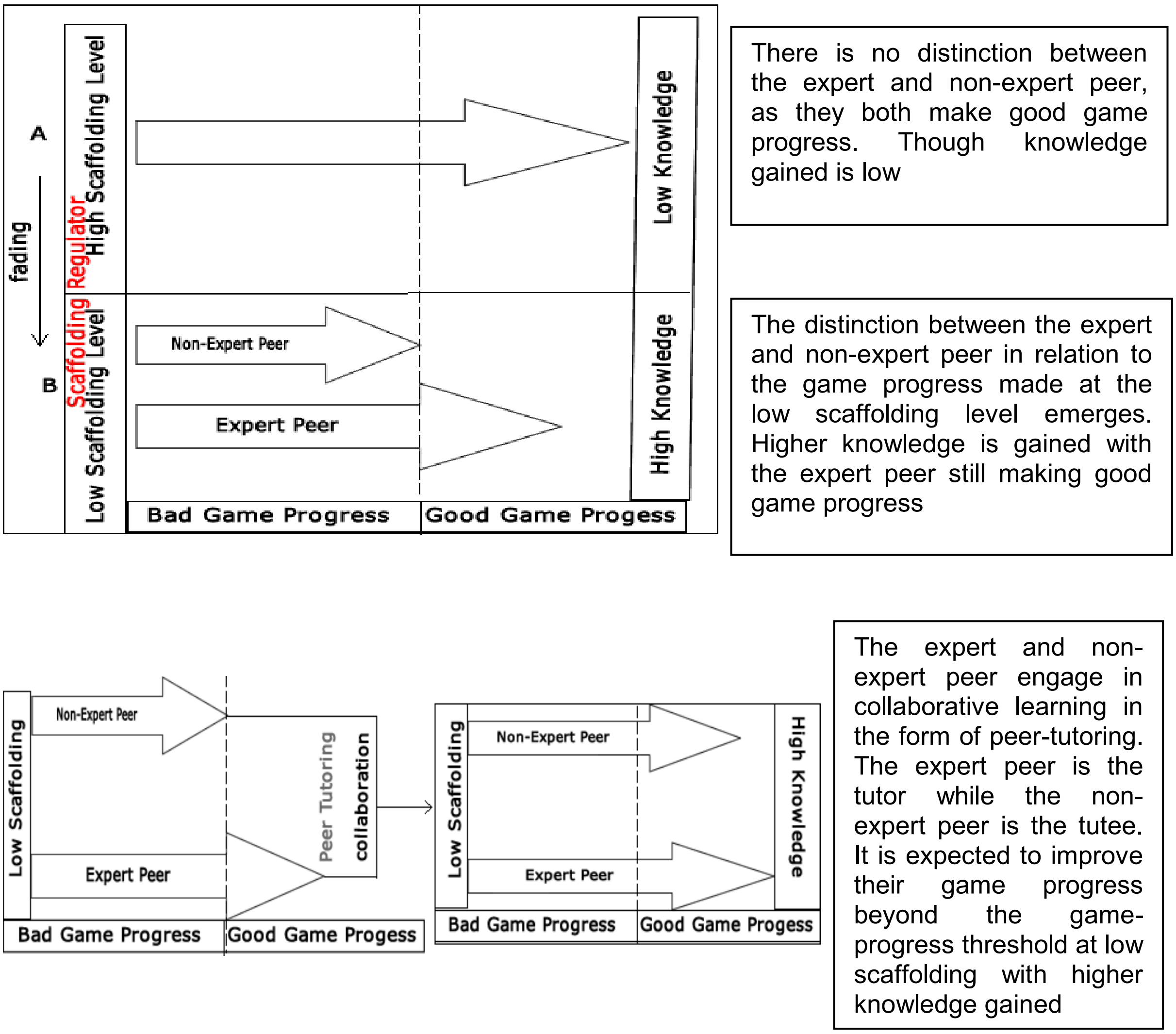

Figure 1: The "fine-tuning system" (FTS)

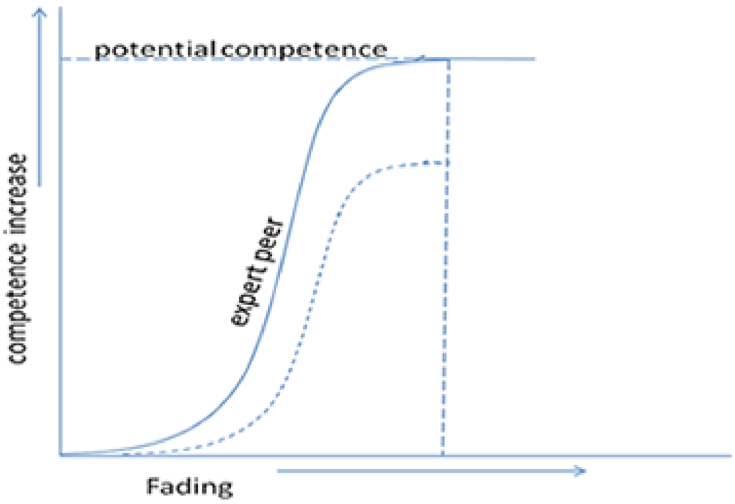

Figure 3: Graphical illustration of the relationship between a child's competence and fading

11. Challenges and limitations

The capture and use of the Learner log

The learner log should contain information related to the Learner-game and Learner-teacher interaction.
Learner-game interaction: From this interaction it is expected that individual data such as the time-spent on game-play, number of attempts and progress report should be captured by an e-learning system. This is a challenge as most game design tools are not compatible with the available e-learning systems.

Learner-teacher interaction: The e-learning system should be able to capture relevant information that would enable the teacher monitor individual player-learner's progress and respond appropriately. The teacher might have to assume a variety of (sometimes challenging) roles (Arnab, et al., 2012). The teacher is also faced with the challenge of determining an appropriate fading-rate based on player-learners' learning rate. Furthermore the teacher determines at what stage in the process, collaboration (peer-peer interaction) becomes expedient. Blending video games with classroom learning might facilitate the adoption of constructivist epistemology at classrooms, where the objectivist perspective is still at the centre today (Tuzun, 2007). "Constructivism is an epistemology used to explain how people know what they know. The basic idea is that problem-solving is at the heart of learning, thinking and development. As people solve problems and discover the consequences of their actions – through reflecting on past and immediate experiences – they construct their own understanding." (Lamon, 2002) "According to constructivism theory, learners construct knowledge (rather than acquiring it) individually through their interactions with the environment (including other learners) based on their current as well as prior knowledge, authentic experience, mental structures, and beliefs that are used to interpret objects and events in relation to the context and environment in which learning takes place. The learner is an active processor of information and creator of personal knowledge" (Thomas, 2010). "Objectivism sees knowledge as a passive reflection of the external, objective reality. This implies a process of "instruction," ensuring that the learner gets correct information".

Peer-Peer Interaction: Peer-tutoring is the collaborative learning style recommended in this paper. There are other collaborative learning styles such as reciprocal peer-tutoring which could be useful. The teacher facilitates the collaboration and is thus faced with the challenge of determining which style would best suit the learners. The classroom culture is also an hindrance here, as "(1) The teachers have seldom experienced classrooms being run in a collaborative fashion (2) The culture of schools does not foster collaboration work by teachers themselves (3) The dominant values in today's schooling, especially under the influence of hyper-accountability emphasise individualism" (Watkins, 2009).

Technical Limitation

"Time alone is not sufficient for video game implementation in a school context and it should be supported by a reliable, strong and available information technology (IT) infrastructure" (Tuzun, 2007). Unavailability of computer laboratories is a hindrance to the successful implementation of any game-based learning strategy. With current student volumes, computer laboratories where available can barely be enough for teaching about basic IT skills (Tuzun, 2007).

12. Conclusions and future research

The zone of proximal development, scaffolding, and dialogue are especially useful concepts or frameworks for school learning (Tinzmann, et al., 1990). Dialogue, scaffolding, and working in one's zone of proximal development can be accomplished in collaborative classrooms (Tinzmann, et al., 1990). The proposed system (FTS) is designed to help drive Problem solving through scaffolded game-play. It recommends adapting instructional support to learner need against adapting learner needs to rigid instructional support. Designers of serious games need to consider the target group's ZPDs, while introducing the "scaffolding regulator" feature to serious games, since the "scaffolding regulator" is used in the calibration of instructional support. Neglecting fading could lead to expertise reversal effect which can deter the learning effectiveness of the game. The whole framework aims at helping dependent learners complete tasks independently by impacting their individual ZPDs through

 ISSN 1479-4403

effectively scaffolded game-play and peer-tutoring. In future work, we will aim to test this system (FTS) and thereby validate its usability for teachers and the classroom environment.

The benefits of this approach open up potential for adopting PBL in classrooms through game-play. Further research will evaluate the framework within the context of a serious game with children aged 10-11 in order to be able to make modifications or generalizations to the framework

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